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Power Plant Automatic Trip and Synchronization Push SMS

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ABSTRACT

Communication plays a very vital role during normal power plant operation. When there is a system fault or even a scheduled outage, information needs to be passed to supervisors and maintenance team, but due to the complexity and challenges that result from the sending processes whereby there is delayed communication which in turn results to prolonged downtime of the unit.

An automatic push sms system offers a solution to this problem; this system is programmed in a way to generate a sms and send it to all recipients required .The sms is triggered by the opening or closing of the Generator circuit breaker (GCB).

The system is programmed to send a sms when the plant has tripped and when the plant has synchronized.

The current push sms is human intervened, one has to log in, type a text then send it to the people concerned. This is a challenge since it may lead to delay, an operator may forget to text due to enormous duties after the machine has tripped or system (internet) may be down at the time of trip.

The system will use a stable mobile network from any service provider.

1. INTRODUCTION

1.1 Background of the study

The Arduino controller is the brain of the automatic push SMS system. It is responsible for automatically sending SMS to a recipient away from the power plant when plant has either tripped or synchronized.

It is important to ensure that once there is a machine trip the information is given within the required time frame so as to avoid long down time which will in turn save the company's production of the megawatts. Thus it is mandatory to provide efficient and reliable communication system.

In this paper the in-house study, design and prototyping of a more robust communication process is perceived as an achievement.

1.2 Problem statement

During normal power plant operation, communication plays a very vital role, when there is a system fault or even a scheduled outage.

This information needs to be passed to supervisors and maintenance team.

Due to the complexity and challenges that result from this processes at times there is delayed communication that in turn results to prolonged downtime of the unit.

The information need to be relayed to several management teams and the relevant maintenance team instantaneously which is not possible.

This is because of the

1) Tedious steps followed when manually sending Kengen push text
2.) Operators require concentration so that they find exact reason that has tripped the unit, this is because most trips are indirect and the cause is unknown at first.
3.) Operators need to safely shut down the BOP
4.) The internet services at times break down which means also the push sms won't work since to access the company's push sms internet has to be there.

1.3 Research Question

It is well known in science and technology that artificial intelligence is gaining a lot of ground in the design of robust controllers that have concept cognitive capabilities.
Faced with the above problem, the question is whether such advancements in artificial intelligence can avail a more reliable and less costly the automatic push sms system controller design that can be applied in KenGen power plants.

1.4 Proposed Solution

The above research question is worth pursuing.
As a found and possible solution, this is what inspires the presentation of this paper.

- An automatic push sms system offers a solution to this problem,

- ❖ This system is programmed in a way to generate sms and send it to all recipients required.
- ❖ The system is programmed to send sms when the plant has tripped/ Normal opening of the Generator CB and when the plant has been synchronized back to the grid.

1.5 Objectives

The objective of this paper is to highlight the design of the prototype and present it as a KenGen-in-house technique.

- To increased company profit margins;
  in a day OLK 1AU generates approximately Ksh 12.4 M. In every 1 Min Olk 1 AU makes approximately **4,305/=** per unit.
  If machine Trips and information is delayed
  for 60 minutes, this will eat up the synchronization time by the same 60 minutes hence we end up losing **258,300/=** Per hour.
- Reduce response time from 1 hour to 10 Minutes
- Increased Plant availability due to reduced response time.

It is foremost that the objective of this paper is to present for approval, the design and its cost benefit analysis to Decision Makers and

Stake Holders attending the G2G Innovation Seminar, 2018

2.0 LITERATURE REVIEW

Scholarly and industrial research studies on technologies for push sms system have been conducted previously. Studies on these technologies

have a rich history and many findings have already been presented. Based on implementation of some of the previous findings, personnel and equipment

in many power plants around the world have continued to enjoy efficiency and time management due to instant responses. A lot of literature nonetheless, have continued to highlight and

compare or contrast between previous studies.

3.0 METHODOLOGY

The methodology applied to address the research question posed in this paper includes reasons for the Automatic push SMS System and an explanation of its theory. Since the technique is in the field of

computer science Electrical technology, this entails subsequent description of hardware and

software design. But designs require testing. Thus, experimentation is considered the right approach towards testing. This will avail data to be used for building the prototype. It will be collected

Real-time so that it can be trusted. Specific experiments will be conducted

Using a prototype method.

3.1 DCS system

In every modernized electricity generating company, Distributed control system is the heart of each and every operation. This is a computerized control system for a process or a plant usually with a large number of control loops, in which autonomous controllers are distributed throughout the system but there is a central operator supervisory control.

In generation of electricity, in case there is a fault in the system, the DCS will send a command signal to the Generator CB to operate (open). Likewise, when all condition has been met and the power is to be connected to the grid. The DCS system will send a command signal to the GCB Instructing it to close (Synchronization).

3.2 Generator CB

GCB is an atomically operated electrical switch designed to protect an electrical circuit from danger caused by over current and many other parameters, i.e. prevent generator from motoring.

Its basic function is to interrupt current after a fault is detected.

Most of GCB Used in geothermal power plants is manufactured by ABB due to the following advantages:

- Fully type-tested exceeding the mandatory requirements of the latest GCB standard IEC/IEEE 62271-37-013
- Equipped with a hybrid cooling system design based on the most advanced passive heat pipe technology, patented by ABB
- Features HMB-8 from the most reliable* spring operating mechanism family to provide safe performance throughout the entire lifespan of the GCB

- Developed to protect the most demanding generator applications, having a rated generator-source short-circuit breaking current of 160 kA according to G2 class**
- Fully assembled and factory tested, brings substantial savings in time and cost for installation and commissioning

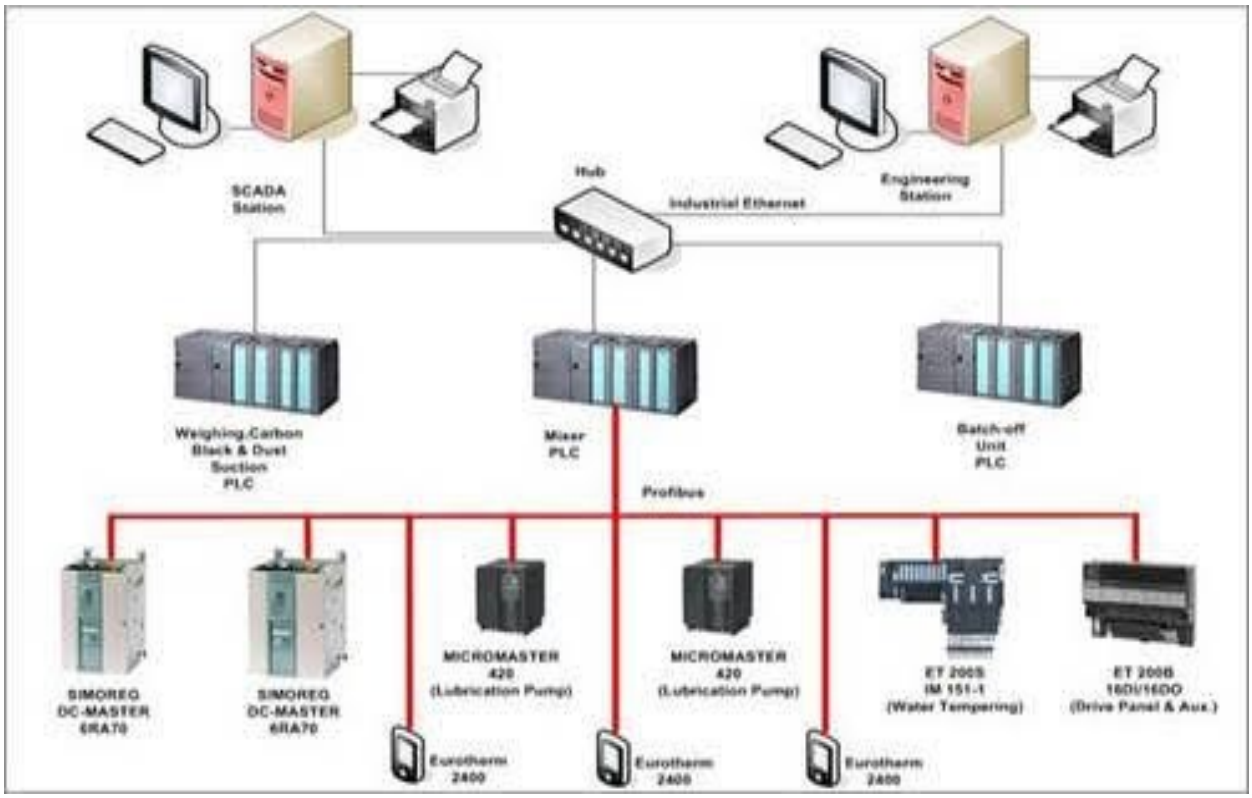

Fig 1: DCS System used in a power plant (Source Wikipedia)

Fig 2: Generator Circuit Breaker(ABB)

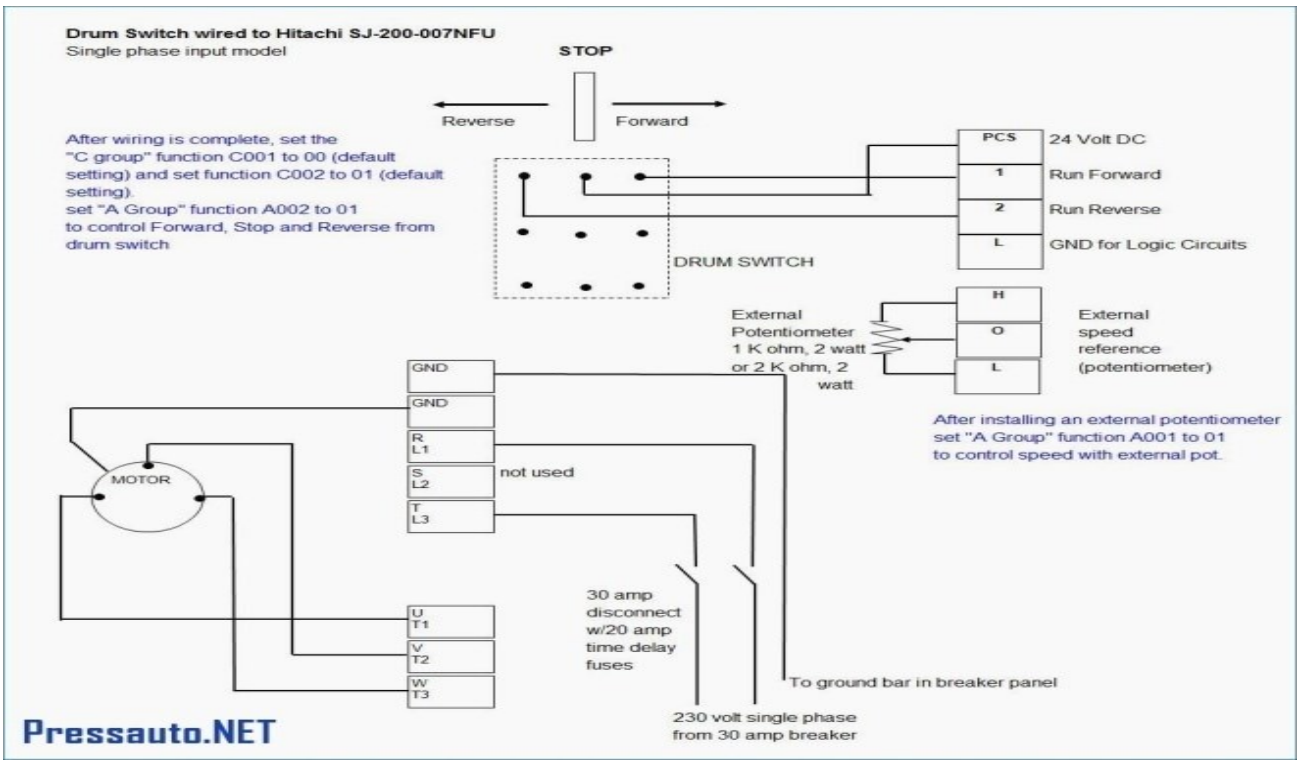

Fig 3: GCB Connection Circuit diagram (Pressauto.NET)

3.3 The microcontroller

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board.

To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments.

All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

Why Arduino?

Thanks to its simple and accessible user experience, Arduino has been used in thousands of different projects and applications. The Arduino software is easy-to-use for beginners, yet flexible enough for advanced users. It runs on Mac, Windows, and Linux. Teachers and students use it to build low cost scientific instruments, to prove chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instruments. Makers, of course, use it to build many of the projects exhibited at the Maker Faire, for example. Arduino is a key tool to learn new things. Anyone - children, hobbyists, artists, programmers - can start tinkering just following the step by step instructions of a kit, or sharing ideas online with other members of the Arduino community.

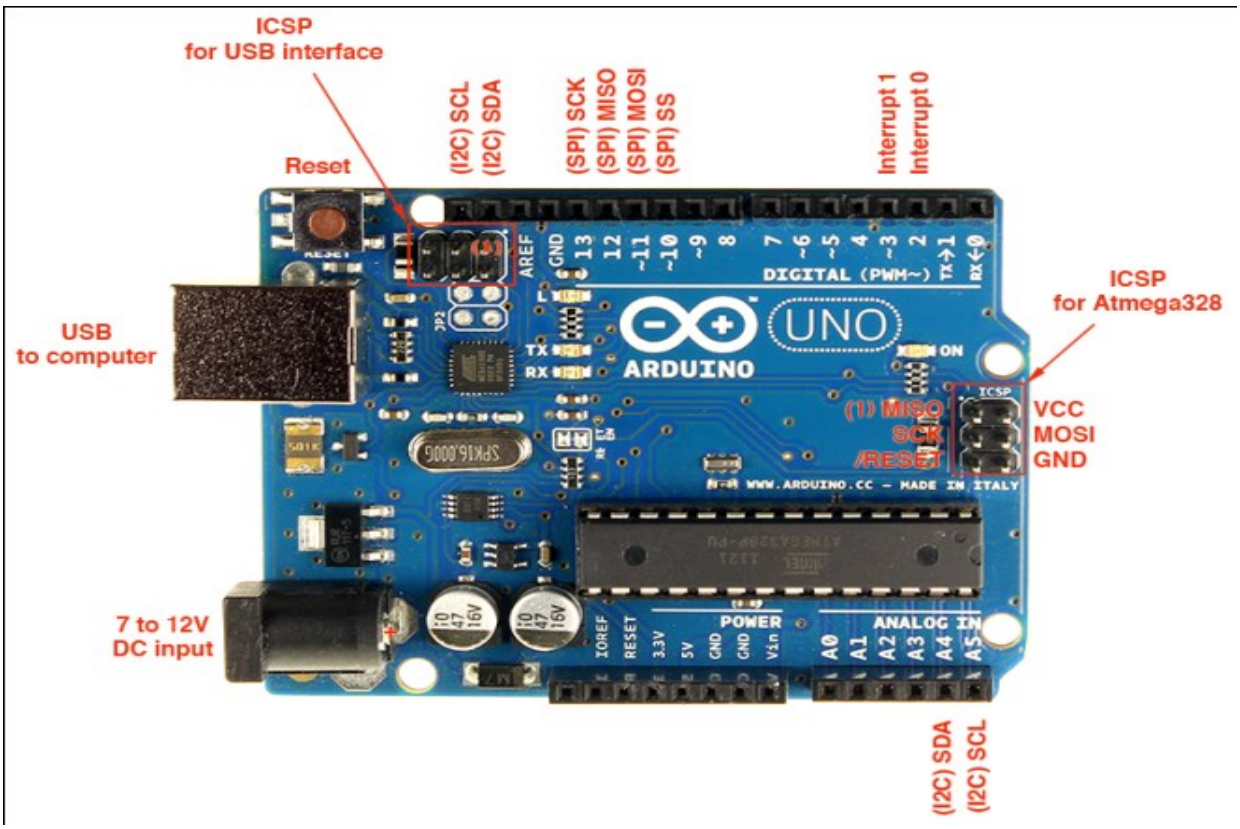

Fig 4: Arduino (Wikipedia)

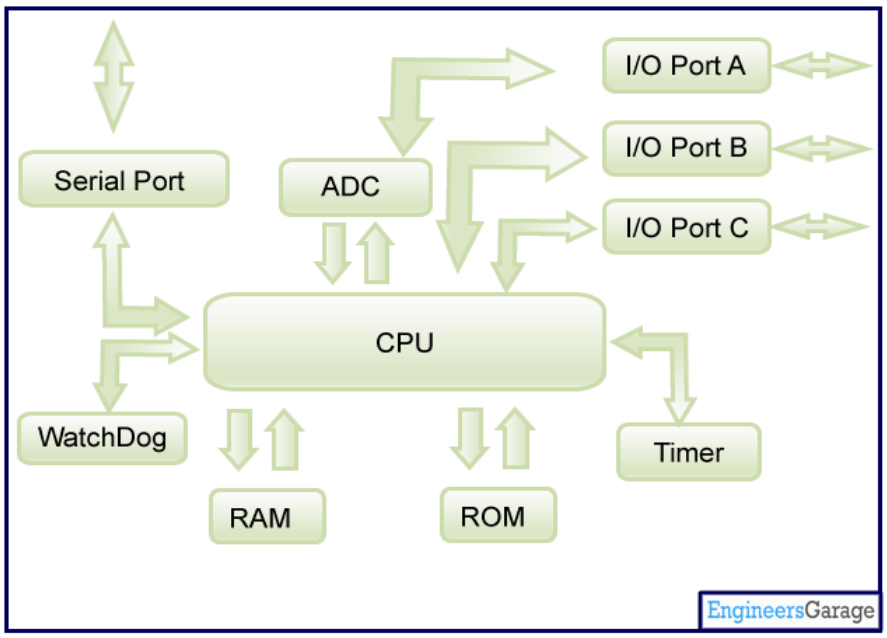

Fig 5 General structure of a microcontroller (EngineersGarage)

There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Net media's BX-24, Phidgets, MIT's Handy board, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50

- Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.
- Open source and extensible software - The Arduino software is published as open source tools, available for extension by
- Experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.
- Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

3.4 GSM (Global system for mobile)

The GSM system uses TDMA to split a frequency into time slots.

Probably the most useful thing to know about the Global System for Mobile communications (GSM) is that it is an international standard. If you travel in Europe and many other parts of the world, GSM is the only type of cellular service available. Originally, the acronym GSM stood for GroupSpecial Mobile, a group formed by the Conference of European Posts and Telegraphs (CEPT) in 1982 to research the merits of a European standard for mobile telecommunications. Commercial service using the GSM system did not actually start until 1991. Instead of using analog service, GSM was developed as a digital system using TDMA technology.

Using TDMA, a narrow band that is 30 kHz wide and 6.7 milliseconds long is split time-wise into three time slots. Narrow band means channels in the traditional sense. Each conversation gets the radio for one-third of the time. This is possible because voice data that has been converted to digital information is compressed so that it takes up significantly less transmission space. Therefore, TDMA has three times the capacity of an analog system using the same number of channels

TDMA is the access method used by GSM, as well as the Electronics Industry Alliance and the Telecommunications Industry Association for Interim Standard 54 (IS-54) and Interim Standard 136 (IS-136). GSM implements TDMA in a somewhat different and incompatible way from IS-136. Think of GSM and IS-136 as two different operating systems that work on the same processor, like Windows and Linux both working on an Intel Pentium III. GSM systems provide a number of useful features:

- Uses encryption to make phone calls more secure
- Data networking Group III facsimile services
- Short Message Service (SMS) for text messages and paging
- Call forwarding
- Caller ID
- Call waiting
- Multi-party conferencing

GSM operates in the 900 MHz band (890 MHz - 960 MHz) in Europe and Asia and in the 1900 MHz (sometimes referred to as 1.9 GHz) band in the United States. It is used in digital cellular and PCS-based systems. GSM is also the basis for Integrated Digital Enhanced Network (iDEN), a popular system introduced by Motorola and used by Nextel. The incredible growth of GSM is a big part of why the acronym is now commonly thought of as standing for the Global System for Mobile communications!

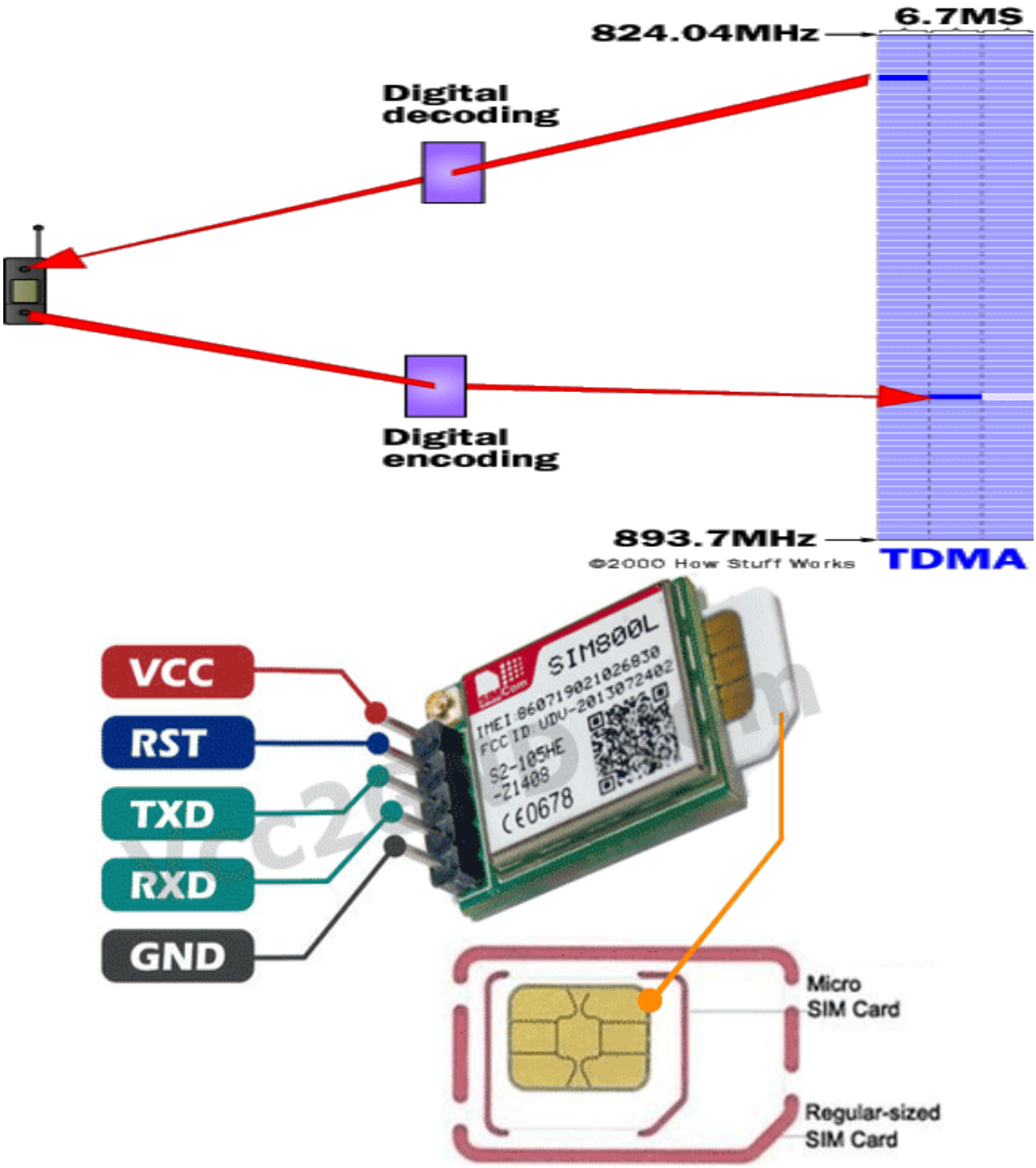

Fig 7: GSM Module (Wikipedia)

Fig 8: GSM Module (Wikipedea)

3.5 Recipient

This is the last stage of the communication channel. This is where the message is outputted. This will include Mobile phones, ipads and pagers.

Mobile phone and Ipad receive the short message from the system which will be displayed on the screen indicating the status of the plant (either plant trip or shutdown i.e. GCB opened or plant synchronized i.e. GCB closed.)

Pagers also known AS BEEPER is a wireless telecommunication device that receives and displays alphanumerical messages. One way pagers can only receive messages while two way pagers can also acknowledge, reply and create messages using an internal transmitter.

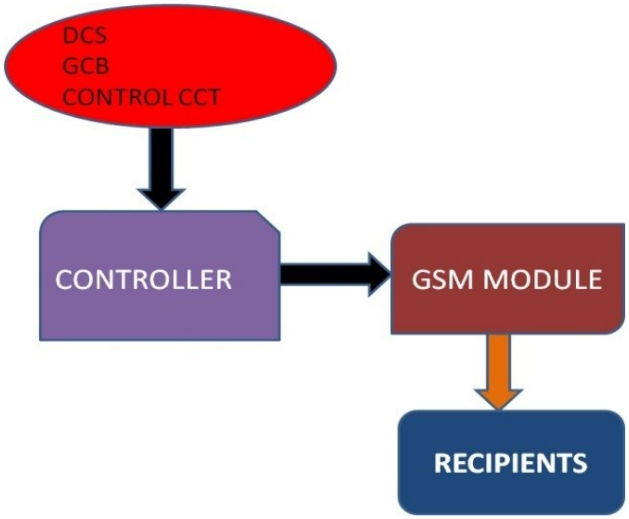

Fig 9: Automatic push SMS block diagram (Circuit maker)

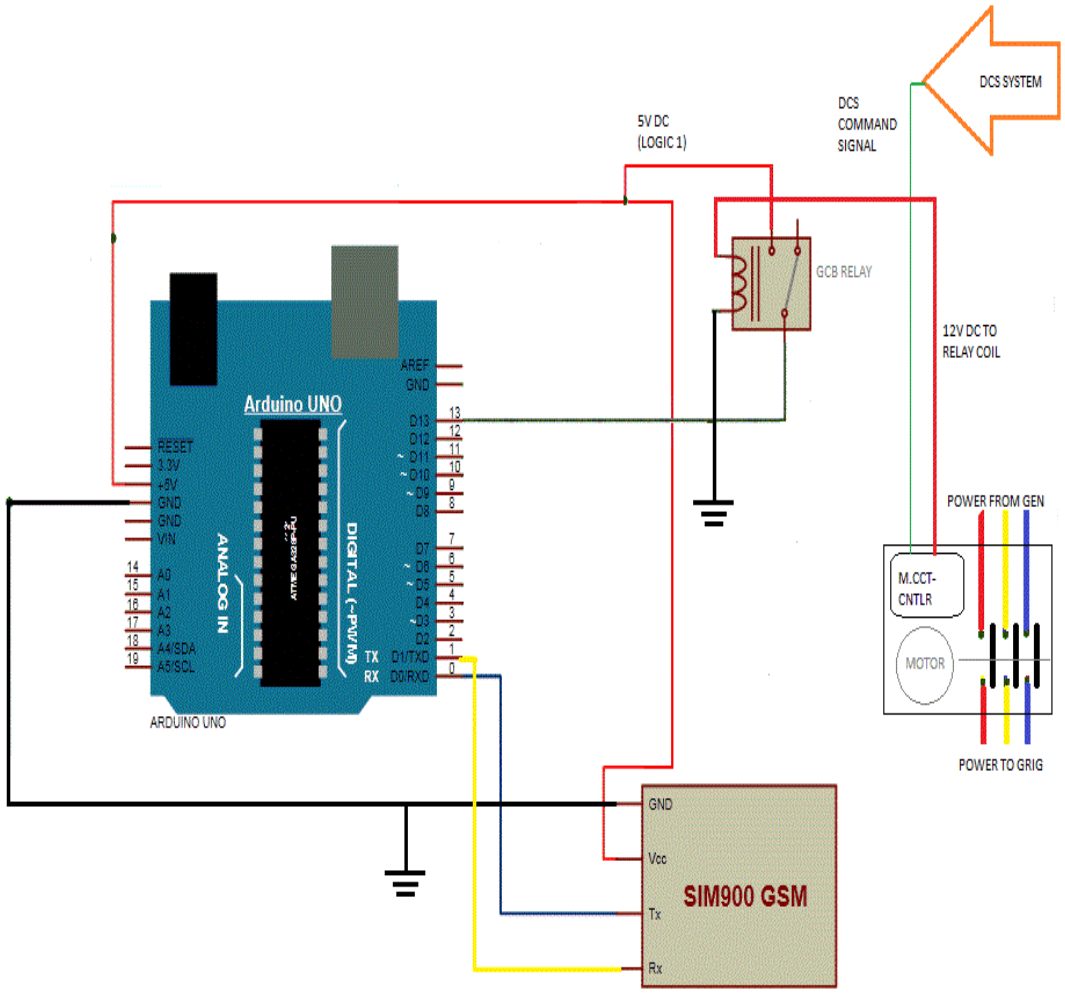

Fig 10: Circuit Diagram (Circuit maker)

4.1 Working Principle of the System

The controller receives either logic 1 or 0 depending on the status of the plant. When the generator CB is open, the controller will receive logic 1 and when the GCB IIs closed, the microcontroller will receive logic 0.

5v dc is supplied at the relay contacts so that to provide logic 0 and 1.

PLANT TRIP/ NORMAL GCB OPPENING

- On the control circuit of the GCB, the (NO) normally open contacts of the relay is connected the five volts supply.
- When the GCB is opened (a trip of the plant/normal shut down has Occurred) a control relay will operate.

- The contacts close which registers a logic 1 on the microcontroller input pin 14.

The microcontroller is programmed to automatically send out pre- typed text to the GSM module which in turn sends the SMS to various recipients that the unit GCB has been opened.

PLANT SYNCHRONIZATION.

- ✓ The GCB control circuit relay's normally closed contact is connected with a five volts supply which is connected to the pin 13 of the controller.
- ✓ When the GCB is open the controller is receiving logic 1.
- ✓ Once the breaker closes and the relay operates and the logic turns to 0.
- ✓ Once the breaker closes and the relay operates and the logic turns to 0.
- ✓ On receiving logic 0, the controller is programmed to send a pre-typed text to the GSM module which in turn sends the SMS to various recipients that the unit has been synchronized.

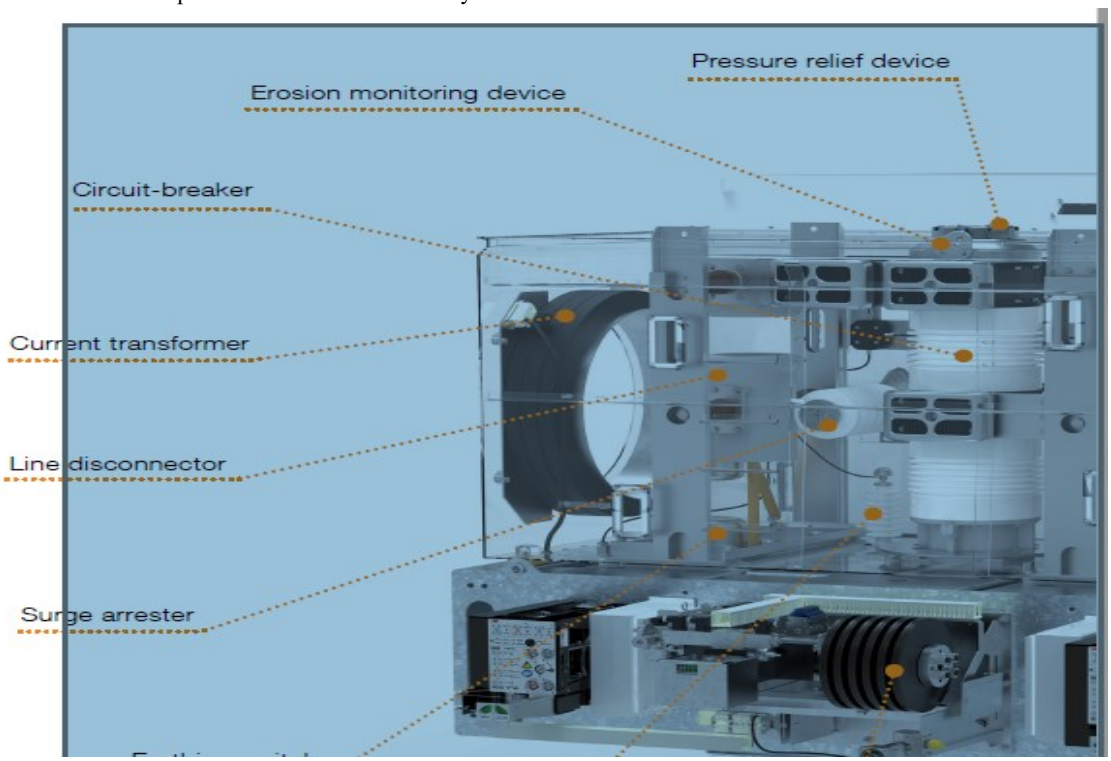

Fig 11 GCB (Wikipedia)

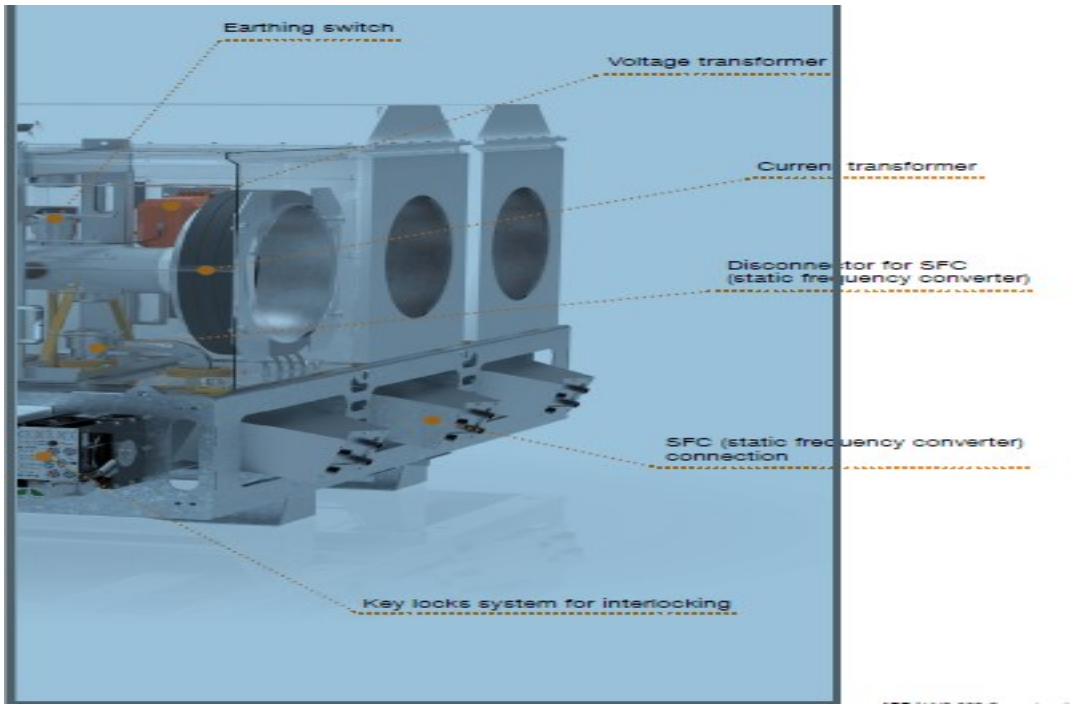

Fig 12 GCB (Wikipedia)

4.3 Code

Plant trip code

final_code_olk_au_push_sms

```
#include "SIM800.h"
#include <SoftwareSerial.h>
#define SIM800_TX_PIN 7
//SIM800 TX is connected to Arduino D7

#define SIM800_RX_PIN 6
//SIM800 TX is connected to Arduino D6

SoftwareSerial serialSIM800(SIM800_TX_PIN,SIM800_RX_PIN);
//Creats software object to comunicate with SIM800
int TRIP = 0;
int SYNCH =1;
//Declares analog ports for trip and synchronization signals

int TRIPValue = 0;
int SYNCHValue = 0;
//Declares initial value for each input signals

int input_signal = 5v
//Declares the approximate value for high input signal
```

Fig 13 Plant trip code

b) Plant synchronization code

final_code_olk_au_push_sms

```
int input_signal = 5v
//Declares the approximate value for high input signal

void loop()
{
  TRIPValue = analogRead(TRIP);
  SYNCHValue = analogRead(SYNCH);
  //Reads the input signals for trip and synchronisation
  delay(500); // This is the time delay at which the signal is send to the arduino

  if (TRIPValue = input_signal)
  //Actual comparison to initiate an assumption of a trip sitiation
  {
    digitalWrite(13, HIGH);
  }
  else
  {
    digitalWrite(13, LOW);
    if (TRIPValue = input_signal)
    //Begin serial comunication with Arduino and Arduino IDE (Serial Monitor)
    while(!Serial);
```

Fig 14 Plant synchronization code

4.4 Cost Analysis

In a day OLK 1AU generates more than Ksh 12.4 M. In every 1 Min Olk 1 AU makes approximately **4305/= per unit.** If machine Trips and information is delayed for 60 minutes, this will eat up the synchronization time by the same 60 minutes hence we end up losing **258300/= .**

Table 1 (Number of GCB Openings during the 2015/2016 Financial year)

Month	Jul-2015	Aug-2015	Sept-2015	Oct-2015	Nov-2015	Dec-2015	Jan-2016	Feb-2016	Mar-2016	Apri-2016	May-2016	June-2016
No of Outages	9	2	4	2	4	0	7	8	10	2	2	4

In July 2015 to June 2016 Olkaria 1 AU experienced total 52 GCB openings. These are both planned outages and Trip

Taking example of the 60 minute delay in reporting, this will eat up the time taken to carry out the job in question which includes diagnosis, planning and repairing of particular equipment. These delays are cascaded to the overall plant availability which eventually reduces as shown in the table oboe.

One of a practical example is on 3rd November 2017 unit 4 tripped because of a problem realised on the circulating water system. The exact problem couldn't be identified immediately because the system was behaving in a funny way making it look like every equipment has failed only to realise that it was only one equipment which had failed and the others were just responding accordingly. It took a lot of time for the operator in charge to find out the problem which leads to wastage of time on informing the maintenance team on the particular problem. So if an automatic push SMS was available it would simplify things as the operator is working on the system the team is already informed and they would be on the way coming. This would save a lot of time cumulatively all through the month hence improving the availability of the plant.

we lost approximately ksh **13.4 M** (258300 * 52) in that financial year.

Sometimes response time might take more 60 Minutes This will translate to more and more revenue loss.

Our project implementation cost

- 5 Volts clean dc power supply.....20000/-
- Arduino microcontroller.....20,000/-
- GSM Module.....74,000/-
- Sim card from a reliable network provider.....200
- Airtime...approximately 2/- per GCB Operation per one recipient.
- Miscellaneous cost.... 100000/-
- Pager.....25000/-.

Total project estimation cost

Ksh 239,200/= per GCB

By implementing this project the company will save on the following;

1. Plant availability will increase to more than 94% due to instant response from Team.
2. Reduce response time from 1 hour to 10 Minutes
3. The information need to be relayed to several management team, at the same time will be solved
4. This will give the operators ample time in that Operators requires concentration so that they find exact reason that has Tripped the unit, this is because most trips are indirect and the cause are unknown at first.
5. Operators need to safely shut down the BOP hence they will concentrate given that the SMS Has been already delivered to the management team

5.0 DISCUSSIONS AND REMEDY

During normal power plant operation, communication plays a very vital role, when there is a system fault or even a scheduled outage.

This information needs to be passed to supervisors and maintenance team.

Due to the complexity and challenges that result from this processes at times there is delayed communication that in turn results to prolonged downtime of the unit.

The information need to be relayed to several management teams and the relevant maintenance team instantaneously which is not possible.

Due to the above problem, an automatic push sms will give a permanent solution to this.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Automatic push sms will eliminate reporting downtime, a short programmed text will be automatically sent to the pre programmed recipients

Instantly whenever there is a GCB opening or closing. At the same time, a pager will sound an alarm so that incase the person does not read a text on time, then he or she will not miss an alarm.

Most hospitals in Kenya have employed this principle of pager.

The system is compatible to most kengen power plants, i.e., Geothermal, Hydro's, thermal and wind.

The automatic push sms can be upgraded so that it can send a detailed text indicating a particular problem example, **'OLK 1 AU UNIT 5 TRIP ON CONDENSER LEVEL HIGH HIGH….0715Hrs'**

ACKNOWLEDGEMENTS

We would first wish to thank God for giving us the inspiration to explore these savings opportunities and give us strength to write this paper. Secondly we want to thank our families for understanding as we had to sacrifice their precious time in meeting the submission deadline. Lastly we would like to acknowledge our colleagues at OLK 1 AU for their encouragement and urging us to push on with the paper.

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Hyundai Engineering company limited: Electrical. Olkaria IAU and IV Geothermal Power Plant Project Key Person Training Packet

John Hiley, Keith Brown and Ian McKenzie Smith HUGHES ELECTRICAL AND ELECTRONIC TECHNOLOGY

BL THERAJA and AK Theraja. Electrical technology in SI Units volume 2 AC and DC Machines